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Original Research Paper

Fostering Innovation and Methodology through Experiential Learning for Data Structures

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Abstract: For real-life work environment, developing employability skills by the students' community is indispensable and need of the hour. Laboratories associated with courses cultivate the ability of students to think independently and promote employability skills through experiential learning. Data structures are one such predominant course in IT/CSE domain to enhance the skill set of students for Placements/Higher studies. It provides opportunity for students to devise algorithms efficiently in an optimal manner by solving challenging problems easily thereby gaining confidence for attending placements. The purpose of this paper is to foster innovation by exploration in data structures course through experiential learning by providing coding based challenging questions as tutorials, assignment presentations and as activities during laboratory sessions and online classes are to be conducted as an essential one in the future learning perspective. Findings conclude that the experiential learning foster student's abilities in solving the problem and thereby gaining confidence during e-learning and placement activities and the grading process are to be updated through centralized servers to the maximum extend and accuracy are to be maintained.

Keyword: Challenging Problems, Data Structures, E-Learning, Experiential Learning, Grading Process.

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1. Introduction

Basically, student community follows the traditional way of learning and executing the programs by following a specific set of defined instructions. However, research purports that there is a profound advances in learning through experience process is required for the betterment of the learning [1]. Nowadays experiential learning is expanding its role in academic institutions to enhance the knowledge and to develop the student's skillset. It is neither a basic action, nor an ultra-sensitive reproduction. It involves solving a highly challenging problem with one's own critical thinking and problem-solving skills. This profound involvement creates better retention of new thoughts [2]. Rather than memorizing the concepts and replicating, activity based experiential learning is considered as a wise choice to learn and understand the concepts clearly. The activities are planned to involve students in higher order reasoning practices or procedures when open challenging problems are provided [3]. As a result, students pay more attention and gain more insight about the problem that is sustained for a longer period of time. Educators plays a crucial role in engaging the students in open ended challenging problems. Curriculum based activity based questions or projects are highly recommended in this paper to improve the student's performance in all aspects. The course considered for investigation of experiential learning is Data Structures, as it is undoubtedly most vital course for CSE/IT placements in the current and future scenario.

This paper is constructed in such a way to reflect the voice and thought of teachers, students and the progressed mode of investigation carried out as activities that leads to improve the involvement of students in academics in a healthier manner and practice in their regular day to day life in an efficient way. Section 2 performs a review for activity based learning methods and concerns of stakeholders involved in the experiential process, section 3 elaborates the innovative experiential learning procedures and components investigated for data structures course and its applicability section 4 explores the case study and section 5 concludes the research paper.

2. Literature Review

2.1. Hypothesis

The literature demonstrates that activity based teaching and learning, highly focused methods of instruction seem increasingly successful in improving students' performance with the support of stakeholder.

2.2. Research Site

Case 1:

A paper by Pereira J.A. et al [4] studies the impact of using multimedia technology to teach anatomy classes. A research was conducted by them with two sets of students from a class. The first group of students was exposed to only theoretical lectures, whereas the second group of students was exposed to both theory and videos related to anatomy. Findings conclude that the students who were exposed to video clips performed well in the exams rather than the other set of students.

Case 2:

According to Singha, et.al [5], a survey was conducted in the state of Assam, India for few school students, college students and teachers. The topic of discussion was teaching and learning math in schools and colleges. The main consideration is about the subject's complexity as it contains many formulas that is very difficult to memorize. To overcome these issues, activity based events related to the math like quizzes, exhibitions showing the models, seminars, refresher courses are recommended to make the subject more interesting to study than by compulsion.

Case 3:

According to research by Stephanus [6], the experiential learning method emphasizes the role of active experience and the involvement of students. Through authentic practice-based learning, students' experiences will lead to the self-efficacy which in turn results in their confidence to handle a specific task.

Case 4:

According to a study conducted by Morris [7], experiential learning consists of contextually rich concrete experience, critical reflective observation, contextual-specific abstract conceptualization, and pragmatic active experimentation.

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Case 5:

According to a study conducted by Egilmez [8], in this study, the researchers focused on investigating the learning effectiveness of an online ethics module developed for and implemented in a senior year Engineering Ethics Seminar course. The module consisted of three pillars: code of ethics, case studies, and methods for applying ethical reasoning. Each pillar requires the student to take a quiz consisting of 4 to 7 questions, and a final 10 question quiz at completion of the module. In-class activities and assignments complement the module. The research team conducted a two-semester assessment on learning effectiveness of the online ethics module with a sample of 41 engineering students from well-represented diverse majors, self-identification and racial/ethnic backgrounds compared to the enrollment population. Results indicate that the proposed online module positively impacted the students' proficiency in knowledge of ethics and ethical reasoning in terms of students' perception of improved confidence and the instructor's assessment.

Challenges:

In the literature carried out in the contribution of other stakeholders to improve the performance of students, the author discusses few major challenges facing by India and steps taken by the government with regard to the problem. Few of the issues listed by the author are: Inadequate infrastructure, less exposure to good research, less number of industry-university tie-ups [9]. Also a recent article by The New Times newspaper [10], an English teacher named Aminadhad Niyoshunti, based on the country Rwanda, suggests that the parental guidance is also required in shaping the behavior of the student.

Solutions:

In the open-ended style, the problem can be approached with multiple ways to attain the efficient solution and there is no most ideal method to put in practice [11]. Henceforth, the students finds complete independence in approaching and exploring the problem in their own drive and innovation [12, 13]. Experiential mode of learning enhances the learning capacity, confidence, creativeness of students and make them industry prepared [14]. Also, it provides a high level of spirit to work like a practiced professional [15]. Hence, the literature emphasizes that experiential learning improves the student's confidence, performance and involvement drastically.

3. Methodology

3.1. Research Design

The course considered for investigation in this paper is data structures as it plays a significant role in Information technology domain placements. The proposed methodology describes the activity based experiential learning carried out in the laboratory and in each and every component of the course. The implementation model, overall impact on students' performance and learning experiences also elaborated in this study. As a part of B.Tech-IT curriculum of PSG College of Technology to strengthen the students' ability in developing and analyzing algorithm efficiently, five courses are included, namely, Data Structures, Design and Analysis of Algorithms, Data Structures Laboratory, Advanced Data Structures and Advanced Data Structures Laboratory. These courses promise in-depth coverage towards Placement preparation/Higher Studies from the second year onwards of student's candidacy.

As a part of these courses, apart from teaching the topics as per syllabus, Tutorial questions are given in the class based on recent GATE Exam question papers and from frequently asked placement questions from various forums. For assignment presentations, coding based challenging questions from HackerRank, CodeChef, GeeksforGeeks, HackerEarth and UPSC are given and the students are advised to come up with multiple independent solutions/methodologies for the same problem by ascertaining the time and space complexity of the program/problem/application. Inherently the students are able to get a clear insight to apply different strategies for the same program/problem/application and analyzing the same. By comparing various methods for the same problem, students are able to approach the same problem in multiple ways to identify the optimal (best) solution as an outcome for this research study. Rubrics also adopted to avoid large variations in the assessment procedure.

During laboratory sessions, placement based questions related to the activity/exercise are given as practice questions for implementation. As an outcome, in-depth knowledge is assured for the respective activity/exercise. To emphasize this innovative pedagogy, few lab tests/Department placement training sessions are conducted in HackerRank as an execution environment to make the

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students familiar with the environment that benefit them during their placements. Students are ranked based on the Cumulative score obtained in the components, namely, Tutorials, Assignment Presentation and Department Placement Training Sessions and appreciated during the IT Association Award Ceremony to motivate the young minds. Students show a lot of interest in developing the optimal solution for contemporary interdisciplinary applications/real world problems with greater independence that leads as a way to Project-based laboratory. Also, while solving the problem as a group, teamwork skills and coordination skills are enhanced among the students and able to manage the competitive and stressful environments.

3.2. Experiential Learning vs. Traditional Learning

A detailed comparison and benefits of experiential learning vs. traditional learning is presented in Table 1.

Table 1. Comparison of Experiential Learning with Traditional Learning

Activities/Skills	Experiential Learning	Traditional Learning
Briefing on theory, tutorial questions, assignment questions and laboratory questions	*X*	√
Deriving execution model	√	*X*
Designing multiple solutions for a problem	√	√ *(To some extent)*
Identifying the optimal (best) solution	√	√ *(To some extent)*
Assurance of in-depth knowledge	√	*X*
Creativity & analyzing skills	√	*X*
Exploration & interpretation skills	√	*X*
Gaining motivation & self-confidence	√	X

4. Finding and Discussion

4.1. Data analysis

42 students were chosen as a case study for a detailed analysis on experiential learning in 2017/2018 and 70 students were chosen for a case study in 2019/2020. High level challenging questions was posted to students during laboratory sessions and as tutorial as a trial. Prior to the contest, students were briefed about the working in the environment. A detailed note on solving challenges/problems in the practiced environment is demonstrated.

Pictorial representation of the contest statistics is shown in Figure 1.

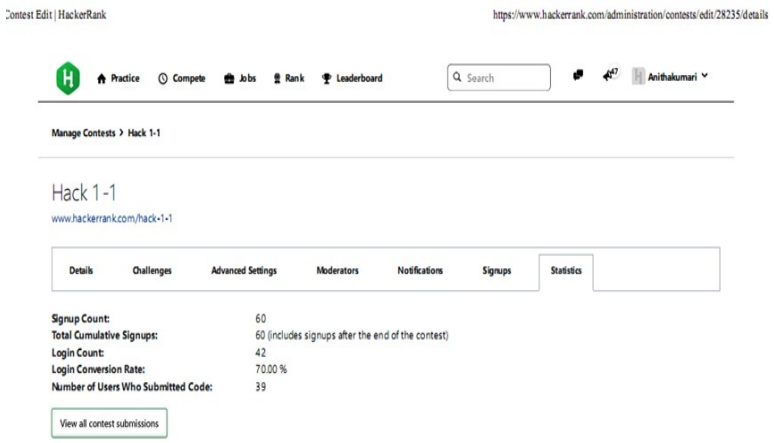

Figure 1. Hacker Rank Contest for Data Structures

International Journal of Education, Science, Technology and Engineering, vol. 4, no. 1, pp. 24-33, June 2021. **DOI: 10.36079/lamintang.ijeste-0401.176**

The contest is conducted on the HackerRank platform for highly challenging questions where all possible test cases and restrictions are added and given as input. Students are highly prepared and eagerly participated in the contest for gaining an experiential mode of learning. Lecturers are not required, but initially present to facilitate the students.

From student's side, a complete independence is provided in selecting the programming language for execution. A systematic way of executing the contest was discussed with students with 4 hours on-lab session initially and dropped to 3hours on-lab session later.

Scores obtained after successfully submitting the code are encountered as their component marks for data structure course. The scores obtained by the students are shown in Figure 2.

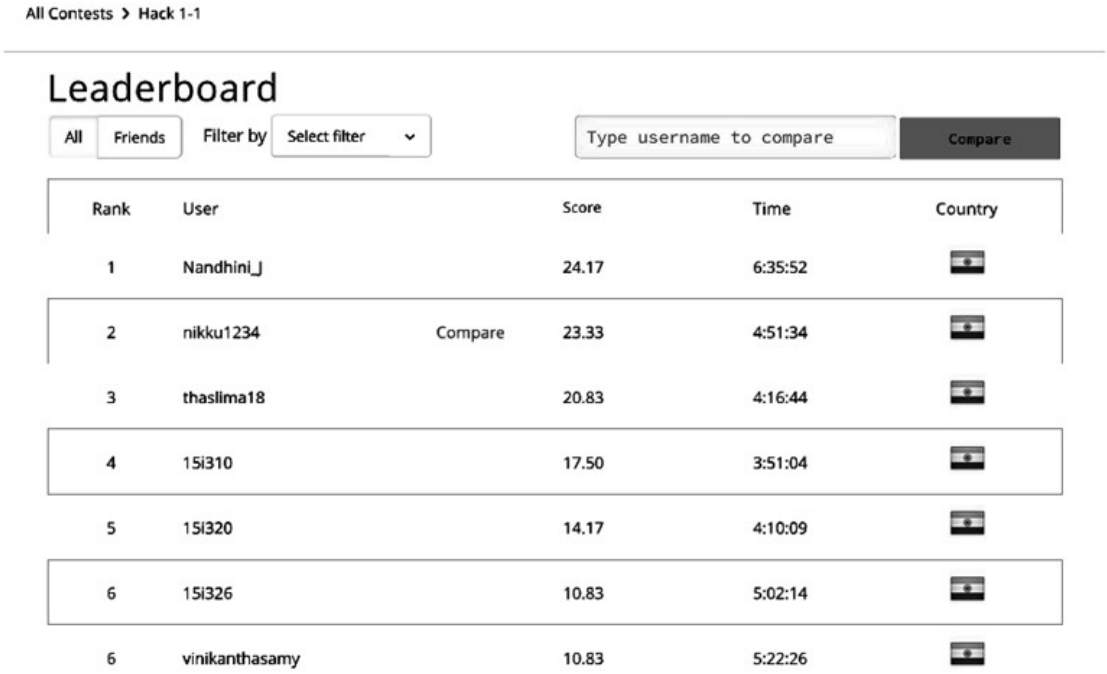

Figure 2. Leaderboard: Scores of Students in 2017/2018

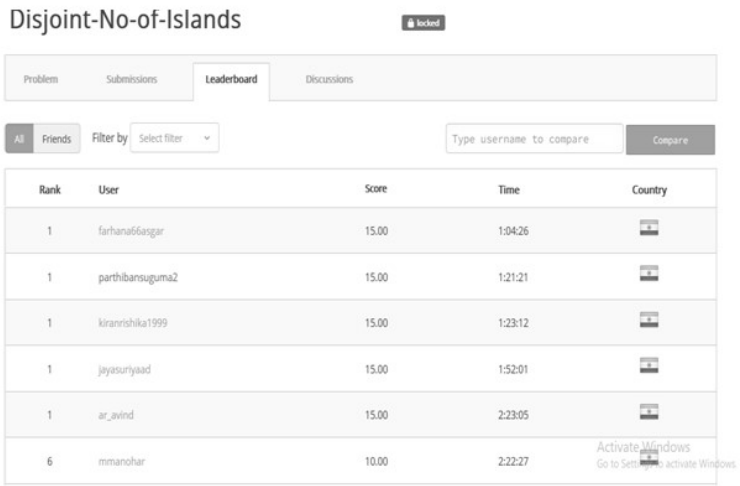

Figure 3. Leaderboard: Scores of Students in 2019/2020

International Journal of Education, Science, Technology and Engineering, vol. 4, no. 1, pp. 24-33, June 2021. **DOI: 10.36079/lamintang.ijeste-0401.176**

As the score analysis is a versatile tool to measure the efficiency of the students, it is considered as a metric in our study to measure the strength and weakness of students. Out of 42 students attended the contest, 39 students successfully submitted the code.

From Figure 4, our analysis revealed that, 3 students completed the programs in an exceptional manner by providing an effective solution satisfying all test cases. 30 students are very likely to perform well and the analysis discloses that high/extra attention required for 6 students. It's quite a remarkable result that facilitates to identify the position of students.

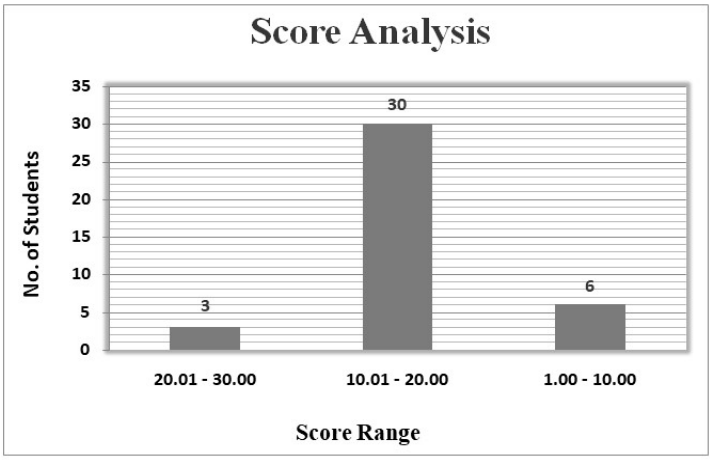

Figure 4. Score Analysis

This acts as an evidence that students' participation in experiential learning facilitates to improve their performance in a better manner by knowing where they are standing in than the traditional way of learning. In summary, our findings emphasize that experiential learning enhances students analyzing skills and paves way for improvement in the academics.

4.2. T-Test

It is used for comparing two groups based on their mean scores-test is based on t-distribution and is considered an appropriate test for judging the significance of a sample mean or for judging the significance of difference between the means of two samples in case of small samples when population variance is not known.

In case of two samples are related paired t- test for judging the significance of the mean of difference between the two related samples.

4.3. Null Hypothesis

There is no significant difference between experimental learning and traditional learning in the various rating given by the respondents.

4.4. Group Statistics

Group statistics are presented in Table 2 and Table 3.

4.5. Interpretation

Since SIG value is less than 0.05, for Deriving execution model, designing multiple solutions for a problem, identifying the optimal (best) solution, Assurance of in-depth knowledge Creativity & analyzing skills Exploration & interpretation skills, Gaining motivation & self-confidence null hypothesis is rejected. Therefore there is rating difference in all the parameters among Experiential Learning and Traditional Learning, From the T test we can conclude that Experiential Learning is better and optimal when compared to Traditional Learning.

International Journal of Education, Science, Technology and Engineering, vol. 4, no. 1, pp. 24-33, June 2021. **DOI: 10.36079/lamintang.ijeste-0401.176**

Table 2. Group Statistics-1

Parameters	Activity/Skills	N	Mean	Std.Deviation	Std.Error Mean
Briefing on theory, tutorial questions, assignment questions and laboratory questions	Experiential Learning	30	3.2747	0.39514	0.04717
	Traditional Learning	12	3.2080	0.46415	0.10283
Deriving execution model	Experiential Learning	30	3.1713	0.46455	0.05507
	Traditional Learning	12	2.1760	0.26287	0.07377
Designing multiple solutions for a problem	Experiential Learning	30	3.1973	0.39318	0.05757
	Traditional Learning	12	3.1200	0.44377	0.12075
Identifying the optimal (best) solution	Experiential Learning	30	2.7600	0.28899	0.03347
	Traditional Learning	12	2.7800	0.38078	0.07816
Assurance of in-depth knowledge	Experiential Learning	30	3.1810	0.98740	0.11450
	Traditional Learning	12	3.1080	0.88462	0.09723
Creativity & analyzing skills	Experiential Learning	30	3.1877	0.99472	0.22453
	Traditional Learning	12	3.1869	0.36127	0.011452
Exploration & interpretation skills	Experiential Learning	30	3.4678	0.999172	0.06789
	Traditional Learning	12	3.4589	0.33042	0.06950
Gaining motivation & self-confidence	Experiential Learning	30	3.4567	0.33452	0.06648
	Traditional Learning	12	3.1456	0.23145	0.14752

International Journal of Education, Science, Technology and Engineering, vol. 4, no. 1, pp. 24-33, June 2021. **DOI: 10.36079/lamintang.ijeste-0401.176**

Table 3. Group Statistics-2

PARAMETERS	VARIANCES	Levene's Test for equality of Variances		T-test for Equality of Means		
		F	Sig.	t	df	Sig. (2 -tailed)
Briefing on theory, tutorial questions, assignment questions and laboratory questions	Equal variance assumed	1.090	0.258	0.553	40	0.457
	Equal variance assumed	4.397	0.033	1.504	40	0.090
Deriving execution model	Equal variance assumed	0.016	0.634	1.520	40	0.031
	Equal variance assumed	0.403	0.380	1.403	40	0.123
Designing multiple solutions for a problem	Equal variance assumed	0.678	0.480	0.531	40	0.021
	Equal variance assumed	0.146	0.146	0.124	40	0.124
Identifying the optimal (best) solution	Equal variance assumed	1.146	0.186	0.146	40	0.003
	Equal variance assumed	0.416	0.345	0.452	40	0.090
Assurance of in-depth knowledge	Equal variance assumed	1.176	0.478	1.145	40	0.040
	Equal variance assumed	0.145	0.123	1.789	40	0.668
Creativity & analyzing skills	Equal variance assumed	4.456	0.356	2.172	40	0.001
	Equal variance assumed	2.256	0.145	2.145	40	0.949
Exploration & interpretation skills	Equal variance assumed	2.146	0.785	1.124	40	0.042
	Equal variance assumed	1.236	0.169	0.121	40	0.543
Gaining motivation & self-confidence	Equal variance assumed	3.456	0.998	0.025	40	0.003
	Equal variance assumed	2.412	0.124	0.456	39	0.372

International Journal of Education, Science, Technology and Engineering, vol. 4, no. 1, pp. 24-33, June 2021. **DOI: 10.36079/lamintang.ijeste-0401.176**

5. Conclusion

As an inference, this restructured mode of learning for the courses Data Structures, Design and Analysis of Algorithms, Data Structures Laboratory, Advanced Data Structures and Advanced Data Structures Laboratory results in stimulating the students' creativity, analyzing skills, exploration skills, interpretation skills and thereby gaining motivation and self-confidence. With high level of confidence, designing efficient (best) solution during interviews becomes reality and thereby results in the continued growth of the department and institution this also is confirmed by the statistical T-test.

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International Journal of Education, Science, Technology and Engineering, vol. 4, no. 1, pp. 24-33, June 2021. **DOI: 10.36079/lamintang.ijeste-0401.176**

Biography

Dr. K. Anitha Kumari is working as an Associate Professor in Department of IT in PSG College of Technology, India. She is Highly Passionate and curious about Learning New stuffs in Security Protocols. As an Independent Researcher, she had an Opportunity to present her paper based on Quantum Cryptography in USA and visited a few Foreign Universities. To her credit, she had filed a PATENT and published around 50 Technical Papers in refereed and Impact Factored International/National Journals/Conferences published by Elsevier, Springer,T&F,Etc.,.Also, she's been an Active Reviewer for Prestigious Journals published by Springer,Wiley,etc.,and Technical Program Committee (TPC) for CECNet 2017, NGCT-2017 WICC-2018 and NCCI-2018 conferences. Her areas of interest include Cloud & IoT Security, Design and Analysis of Security Protocols, Attacks & Defense, Security in Computing, Bioinformatics, Cognitive Security, Quantum Cryptography, Web Service Security, Network Security and Analysis of Algorithms. Out of her research interest, she has contributed a Book chapter in T & F and delivered ample Guest Lectures. Her security project is Recommended by AICTE for a sum of Rs.20,00,000/-. She's been the mentor for Technovator Projects (2018 & 2014) and 'MEDROIDZ', an ICICI – Trinity 2014 funded project that was selected as one among the 6 projects in India. Academically, she has secured RANK-I and awarded Gold Medal in ME (SE) & in BE (CSE) from Anna University and from Avinashilingam University. She won prizes in intra and inter institutional cultural events. As a Supervisor, she is currently guiding PhD scholars. You may contact her at anitha.psgsoft@gmail.com / kak.it@psgtech.ac.in.

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